1988/89 Annual Review

Energy Conservation and Renewable Energy Research, Development and Demonstration Program

Alberta
ENERGY
Scientific and Engineering
Services and Research Division

Cover Illustration: During 1988/89, the emphasis of the Energy Conservation and Renewable Energy Research, Development and Demonstration Program shifted toward hydrogen research. Seven projects within the new Hydrogen Technology Research Program were approved for funding in 1989/90.

1988/89
Annual Review

Energy Conservation and Renewable Energy Research, Development and Demonstration Program

Alberta
ENERGY
Scientific and Engineering
Services and Research Division

Pub. No. I/290
ISBN 0-86499-637-3
ISSN 0831-036X

Contents

2 **Director's Report**
5 **Introduction**
6 **Review of Program Projects - 1988/89**
7 Energy Conservation in Buildings
12 Wind Energy
14 Waste Heat Recovery/Low Temperature Heat Utilization
17 Energy Conservation in Industry
19 Hydrogen Technology Research
21 Technology Transfer
24 **Appendices**
25 Appendix A: Summary of Program Expenditures
30 Appendix B: Publications List

Director's Report

Since 1977, when the Energy Conservation and Renewable Energy Research, Development and Demonstration Program began, more than 60 research projects have been undertaken by energy specialists in Alberta. This work was funded in part by the Alberta/Canada Energy Resources Research Fund (A/CERRF). The subjects of these projects have ranged from solar and wind energy, energy conservation in the oil and gas industry, and energy conservation in residential and commercial buildings, to some fundamental studies on fusion energy and hydrogen.

In 1983/84, research emphasis shifted to three general topics, each of which became a subprogram having several projects under way concurrently. These subprograms were:

- Energy Conservation in Buildings;
- Wind Energy; and
- Waste Heat Recovery/Low Temperature Heat Utilization.

By 1987/88, most of the projects initiated in these three subprograms (49 projects altogether) were winding down and two new subprograms were added. They were: Energy Conservation in Industry and Hydrogen Technology Research.

All of these subprograms were active in 1988/89. Also, the publication of technology transfer booklets pertaining to all A/CERRF-funded projects continued this year. This activity is included in the program.

This year, eight research projects were continued from 1987/88. Four were completed and four will continue into 1989/90. Also, a call for proposals was sent out in December 1988 for participation in the Hydrogen Technology Research Program. Nineteen proposals for research projects were received and appraised by a Review and Selection Committee. Seven projects were approved by the A/CERRF Committee for funding in 1989/90.

Funding contributions from A/CERRF for all 1988/89 projects totalled $353 372.

Energy Conservation in Buildings

Three of four projects carried over from 1987/88 were completed this year. The one remaining project in this subprogram, Energy Conservation in Housing, is a multi-year effort. It involves studies of four housing-related technologies using the existing houses of the Alberta Home Heating Research Facility. The four studies entail:

- installation and performance testing of a hydronic radiant floor heating system under controlled conditions;
- selection, installation, testing and evaluation of a gas-fired absorption heat pump;
- development and testing of simple passive ventilators to provide fresh air, air exchange and ventilation in airtight homes; and
- investigation and measurement of moisture migration through typical structural components of a test home.

This project is scheduled to be completed in 1990.

In one of the completed projects (Swimming Pool Dehumidification Demonstration), a pool space dehumidification system and a conventional outdoor air intake and exhaust system installed at the University of Lethbridge Aquatic Centre were monitored individually and evaluated for their ability to conserve energy and provide opportunities to use waste heat.

It was found that both systems were capable of maintaining constant air and pool water temperatures and relative humidity in the pool space. At ambient temperatures below 9.5°C, the heat pump system required less total energy than the conventional ventilation system, but the energy it required (electrical) was more expensive than the purchased energy (natural gas) it displaced. Consequently, the ventilation system experienced lower operating costs.

In the Peak Electrical Demand Reduction project, also carried out at the University of Lethbridge and completed this year, the ability of an existing 1 MW natural gas-powered co-generator to "shave" peak electrical demand was studied. On those occasions when the generator operated, heat was recovered from the engine jacket water and used to preheat the campus heating water before it was returned to the main boilers. The unit was also available as an emergency generator.

It was found that savings associated with peak load shaving were significant. For example, when the co-generator was operated at full output, cost savings of $60 an hour were possible. This is equivalent to a payback period of 7.1 years, assuming capital costs of $400 000 for the co-generator.

The benefits of heat recovery were less significant. Although energy recovered from the engine jacket represented 40 per cent of the net amount of electrical and thermal energy recovered from the system, the associated savings were only 6.6 per cent of the total.

In the last of the three completed projects, the ability of evaporative humidifiers using water-soaked pads or water sprays to provide indoor cooling was measured at the University of Lethbridge. These devices were used under some atmospheric conditions over a typical cooling season (May to October) to reduce the operational time of the refrigeration components of a conventional air-conditioning system.

It was found that the evaporative humidifiers were able to provide the desired level of cooling for approximately 38 per cent of the total operational time for the test period. This reduced the operational time of the chillers by 588 hours, which represented cost savings of $12 400. For the evaporative humidifiers used at the university, these cost savings amounted to a payback period of approximately five years.

This year, it was learned that the City of Edmonton had been awarded the C.N. Densmore Award for Energy Management, which was presented by the Alberta Chapter of the Canadian Public Works Association in October 1988, in recognition of the energy savings that resulted after a low emissivity ceiling was installed at the city's Londonderry Arena. This project was carried out under the Energy Conservation and Renewable Energy Research, Development and Demonstration Program. Since this project was completed in 1987/88, low emissivity ceilings have been installed in several other Edmonton arenas.

Wind Energy

This year, funding was provided for the seventh year to offset partly the costs of operating a site for independent testing of wind-powered and solar-powered water pumpers.

Nine wind turbines and three solar-powered water pumpers were tested this year from May to October. Also, a deep well simulator, built and tested last year, was used all summer with three wind turbines. It performed as expected in allowing simulation of pumping from greater depths than are available at the test site.

Test results continue to support earlier observations that the overall reliability of wind turbines is still not acceptable for sustained market development. Solar systems, on the other hand, are showing excellent performance, reliability and cost effectiveness.

Wind turbines and solar pumpers not tested with the deep well simulator this year will be tested next year.

It became necessary this year to reactivate the delta-blade wind turbine project completed in 1986/87. The manufacturer of this turbine was forced into receivership, requiring A/CERRF to pay for the costs of dismantling the prototype wind turbine located at the manufacturer's plant site. Some of this work was done this year. The remainder must be completed during the summer of 1989.

Waste Heat Recovery/Low Temperature Heat Utilization

Two projects in this subprogram were under way this year. One was completed and the other will continue next year.

In the completed project, Co-generation Assessment Study, a review was made of the technical and economic feasibility of employing co-generation systems in Alberta. It was found that low energy costs made acceptance of co-generation more difficult than in other locations, but that many opportunites existed in Alberta and the use of co-generation ought to be encouraged.

Meanwhile, the Co-generation Demonstration project has proceeded to the monitoring stage. A 115 kW co-generator was installed at an Edmonton dry cleaning establishment and has been operating daily since early December 1988. It supplies electricity and hot water during business hours and shuts down overnight. Its performance and cost effectiveness will continue to be monitored next year.

Energy Conservation in Industry

The only project in this subprogram, Recovery of Energy from Waste, is investigating the feasibility of recovering energy from municipal wastes and is likely to be relevant to smaller Alberta communities.

The town of Olds was selected as a hypothetical site for an energy-from-waste plant. This was partly based on an urgent need in this, and nearby communities, for proper waste disposal facilities.

Sufficient data have been gathered to determine the viability of an energy-from-waste plant at Olds and to specify the plant size. Also, a conceptual design of the plant is being prepared, and its capital and operating costs are being calculated. The final report should be released next year.

Hydrogen Technology Research

Following the completion in 1987/88 of the Hydrogen Technology Inventory Study for Alberta, a joint industry/government steering committee was formed in August 1988 to formulate and oversee a hydrogen technology research and development program for Alberta.

Four major research areas were identified. They are:

- new and/or significantly improved hydrogen production technologies;
- optimum end-uses of hydrogen;
- hydrogen storage/transportation and resource, producer/consumer integration; and
- related material, control and safety aspects.

Calls for research proposals were sent out in December 1988 to prospective participants in the program. Nineteen proposals were received in mid-January 1989, and were appraised by a review and selection committee. Subsequently, the A/CERRF Committee approved seven of these projects for funding in 1989/90.

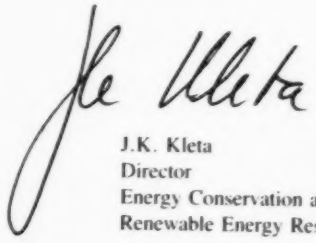
Technology Transfer and Dissemination

Thus far, 30 technology transfer booklets describing 67 energy research projects funded by A/CERRF have been published. Of these, 18 booklets were about energy conservation and renewable energy. Each booklet was distributed to between 300 and 500 energy researchers, technical libraries and energy specialists employed by industry or government.

Program Overview

This year has been a transition period between the types of projects funded by the Program since 1983/84 and those representing an entirely new direction, namely the Hydrogen Technology Research Program.

By next year, activities in all subprograms except hydrogen research are expected to be completed. However, the potential value to industry of the proposed hydrogen research projects could be substantial in the short term and may very well represent important stepping stones toward Canada's energy scene in the 21st century.



J.K. Kleta
Director
Energy Conservation and
Renewable Energy Research

Introduction

Funding for the Energy Conservation and Renewable Energy Research, Development and Demonstration Program is provided through the Alberta/Canada Energy Resources Research Fund (A/CERRF). Contractors who perform funded research also make financial contributions to individual projects.

A/CERRF was established as the result of a 1974 agreement on oil prices between the federal government and the oil-producing provinces. The federal government pledged increased funds to strengthen and diversify Alberta's economy, including $96 million for energy-related research projects. Responsibility for applying and administering the fund rests with the A/CERRF Committee, comprising senior Alberta and federal government officials.

During 1988/89, research activities focused on five main research areas, namely:

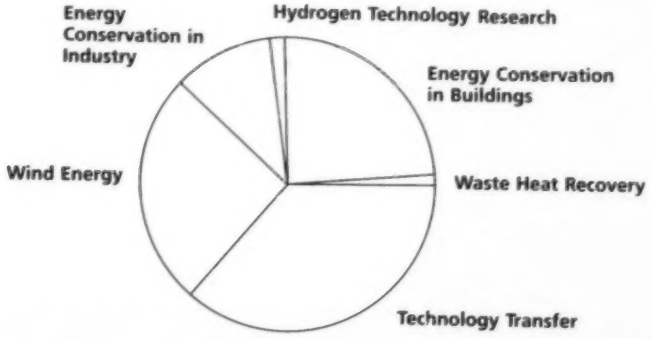
- Energy Conservation in Buildings;
- Wind Energy;
- Waste Heat Recovery/Low Temperature Heat Utilization;
- Energy Conservation in Industry; and
- Hydrogen Technology Research.

Also, production of technology transfer publications is included in the program.

The following section, Review of Program Projects - 1988/89, provides detailed information about individual projects and their achievements, while the financial aspects of past and present projects can be found in Appendix A.

The portion of program expenditures provided by A/CERRF this year amounted to $353 372. It was divided among the five subprograms and technology transfer as shown in Figure 1.

Figure 1: A/CERRF Energy Conservation and Renewable Energy Program Funding Distribution (1988/89)



	Funding ($)	Distribution (%)
Energy Conservation in Buildings	85 321	24.2
Wind Energy	90 532	25.6
Waste Heat Recovery	4 403	1.2
Energy Conservation in Industry	39 036	11.0
Hydrogen Technology Research	5 805	1.6
Technology Transfer	128 275	36.4
TOTAL	353 372	100.0

Review of Program Projects – 1988/89

The following project summaries describe the objectives and principal results of research investigations partially funded by A/CERRF and carried out during 1988/89 in the Energy Conservation and Renewable Energy Research, Development and Demonstration Program. For additional information, contact the Director of Energy Conservation and Renewable Energy Research or the appropriate contractor(s).

Energy Conservation in Buildings

More than one-third of the total energy consumed by Canadians is used to heat their homes, air condition their offices and provide comfortable indoor conditions in other types of buildings where they work or relax.

While this represents a substantial drain on Canada's energy resources, it may also be interpreted as an opportunity that can be turned to advantage. More and more Canadians are discovering that energy conservation at home or at work can help reduce home heating bills or make a business venture more competitive.

Since 1978/79, approximately 40 research, development and demonstration projects related to energy conservation in buildings received financial support from A/CERRF. In most instances, the participants in these projects were not the only ones to benefit. In fact, most projects were sufficiently successful that they have been developed into business opportunities by several entrepreneurs, architects and consultants. Thus, the knowledge acquired and the experience gained from these projects are finding their way into many corners of Alberta.

This year, three projects were completed, while a fourth progressed well and will continue next year. All four are described in the following section.

Swimming Pool Dehumidification Demonstration

Klass Mechanical Enterprises Ltd., Calgary

A pool space dehumidification system and a conventional outdoor air intake and exhaust system, installed at the University of Lethbridge Aquatic Centre, were monitored individually and evaluated for their ability to conserve energy and provide opportunities to use waste heat.

The two-phase project began in January 1986. During Phase I, the contractor reviewed the technology to determine the viability of using heat pump-type dehumidifiers in Alberta. It was concluded that such devices can be cost effective in Alberta and could be used in high-use pools operated by municipalities, universities, hotels/motels and residential complexes.

During Phase II, the two dehumidification systems at the university were operated and monitored independently under similar ambient conditions between September 16, 1987 and March 8, 1988. It was found that both systems were capable of maintaining constant air and pool water temperatures and relative humidity in the pool space.

At ambient temperatures below 9.5°C, the heat pump system required less total energy than the conventional ventilation system, but the energy it required (electrical) was more expensive than the purchased energy (natural gas) it displaced. Consequently, the ventilation system experienced lower operating costs.

The project has been completed.

Demonstration of Free Cooling in Building Humidification Systems

Safronek Pomeroy & Associates Ltd., Calgary

A study at the University of Lethbridge showed that evaporative humidifiers similar to the one shown here should be considered for commercial buildings throughout southern Alberta.

During the summer months in Canada, air-conditioning systems are commonly used to help achieve a comfortable indoor environment. The refrigeration components of most air-conditioning systems, however, can consume substantial amounts of energy over a normal cooling season. An alternative approach, which was investigated in this study, is to obtain cooled air by passing air across water-soaked pads or water sprays.

To determine whether this "free" cooling concept is viable in Alberta, a project was begun in October 1985 at the University of Lethbridge.

Spray coil, cellulose media and refrigeration systems serving University Hall and the Performing Arts Centre were monitored from May 1 to October 31, 1987. This represents a typical cooling season. The primary objective was to determine the number of days a year that evaporative cooling could be used in place of refrigeration. The enthalpy, or heat content, of outdoor air and the degree of indoor cooling were used as the principal criteria in determining whether chillers or evaporative humidifiers would be operated. Records were kept of the time that each system was used.

It was found that the evaporative humidifiers were able to provide the desired level of cooling for approximately 38 per cent of the total operational time for the test period. This reduced the operational time of the chillers by 588 hours, which represented cost savings of $12 400. For the particular wet cellulose and spray coil units used at the university, these cost savings amounted to payback periods of five and six years, respectively. For buildings experiencing less energy efficiency than those at the university, shorter payback periods could be anticipated.

It was concluded that the use of direct evaporative cooling should be considered for commercial buildings throughout southern Alberta.

The project has been completed.

Peak Electrical Demand Reduction Through Co-generation

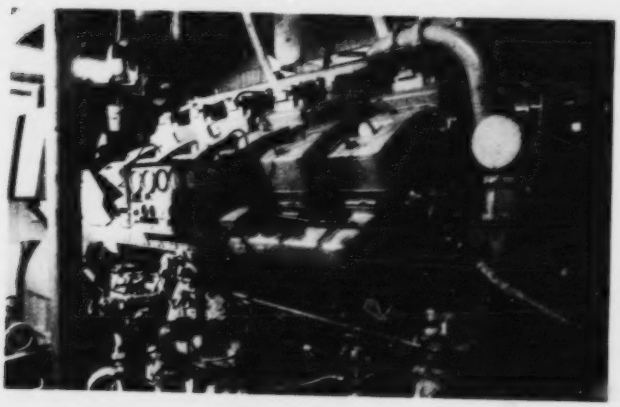
Cheriton Engineering Inc., Edmonton

The emergency generators present in many large buildings are seldom, if ever, used for their intended purpose. Nonetheless, they could be employed regularly to generate electricity on site. This could help reduce the peak demand for power supplied by local utility companies. Also, the heat produced by generators could be recovered and used in some manner. For example, the heat might be used to warm water and displace a portion of the fuel normally purchased for water-heating.

To determine the advantages and disadvantages of this concept, the operation of an existing 1 MW natural gas-powered co-generator at the University of Lethbridge was studied from 1985 to late 1987.

The unit, purchased in 1980, was used initially to "shave" peak electrical demand during the summer months to offset loads created by the operation of water chillers. However, demand for electricity at the university has increased since 1980, causing the co-generator to be used year-round to shave peak loads. On those occasions when the generator operated, heat was recovered from the engine jacket water and used to preheat the campus heating water before it was returned to the main boilers. The unit was also available as an emergency generator.

At the University of Lethbridge, the operation of a 1 MW co-generator (left) and its sophisticated control system (right) was studied to determine the cost effectiveness of using this type of unit to reduce peak demands for electricity.



In evaluating the ability of the co-generator to reduce energy costs, the researchers recognized that the rate structure set by utility companies for large energy consumers comprises two elements: energy charge and demand charge.

From the monitored data pertaining to the energy charge, it was apparent that it was less expensive to purchase electricity from the local utility company than generate it at power loadings of less than 900kW. Above this figure, cost savings of only $2 or $3 an hour could be expected. This, however, is subject to the electricity rates charged at a particular location, since they vary throughout Alberta.

Savings associated with peak load shaving, however, were significant. For example, when the co-generator was operated at full output, cost savings of $60 an hour were possible. At lower output, savings were proportionally smaller. At full output, savings were equivalent to a payback period of 7.1 years. This assumed capital costs of $400 000 for the co-generator.

The benefits of heat recovery were less significant. Although energy recovered from the engine jacket represented 40 per cent of the net amount of electrical and thermal energy recovered from the system, the associated savings were only 6.6 per cent of the total. Therefore, for this installation, heat recovery could not be regarded as the primary economic justification for the co-generator.

The researchers concluded that any decision to purchase a co-generator should be based on peak load shaving and electrical energy savings, whereas heat recovery should be considered only as an added benefit.

The project has been completed.

Energy Conservation in Housing

University of Alberta, Edmonton

Pre-weighed wooden plugs accessible from the outside of one test module are used to determine the amount of moisture that migrates from the inside to the outside of above-ground walls.

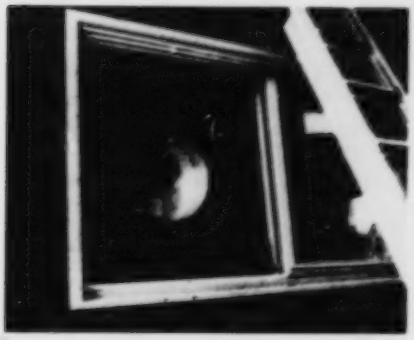
Beginning in 1987, a three-year project was initiated by the Department of Mechanical Engineering, University of Alberta. It involves studies of four housing-related technologies using the existing test modules of the Alberta Home Heating Research Facility. The four studies entail:

- installation and performance testing of a hydronic radiant floor heating system under controlled conditions;
- selection, installation, testing and evaluation of a gas-fired absorption heat pump;
- development and testing of simple passive ventilators to provide fresh air, air exchange and ventilation in airtight homes; and
- investigation and measurement of moisture migration through structural components found in typical residential homes.

Following installation last year of the radiant floor-heating system and monitoring instruments, some preliminary results and observations were reported, but they are for only a short monitoring period. During mid-1988, some flow meters were built for measuring hot water circulation rates in the two main loops in the house. Monitoring is continuing.

The status of international developments relating to gas engine-driven heat pumps using conventional vapour compression and gas-fired absorption heat pumps was reviewed. While the former have been built and are being used in some countries, they are more expensive than electric heat pumps, and are noisier and less reliable. Mostly, they are used in commercial or industrial applications.

Temperature measurements taken at various heights above the floor are used as one indication of the performance of a radiant floor-heating system.



Passive ventilators installed in test modules are being studied as alternatives to mechanical heat-recovery ventilators.

Current low energy costs have caused work on residential units to be suspended. Some gas-fired absorption heat pumps have been built, too, but developments generally lag behind those of conventional heat pumps. More research and development is required before reliable residential units can be released to the marketplace. Furthermore, those units that have been built were tested in climates unlike Alberta's. Although this was one of the reasons for undertaking this project, it was concluded that suitable prototype units simply are not available for testing under Alberta conditions. Therefore, this subproject was terminated.

As an alternative to using exhaust fans or heat recovery ventilators in airtight homes, passive ventilators equipped with dampers may prove to be both satisfactory and cost effective. In this study, a small (15 cm diameter) opening was made in one wall of each of the six test modules at the Alberta Home Heating Research Facility. Each opening was fitted with an electrically operated damper. This was done to provide natural ventilation. In its current configuration, the passive ventilation system is strongly dependent on wind direction. For example, the ventilation rate increases by 50 per cent when the wind is from the south (the intake is located in the south wall), compared with only 10 per cent when it blows from the west.

Based on observations to date, it was decided that passive ventilation data should be collected over a long term for a small number of fixed inlet and exhaust configurations. Some of this data collection began this year. The results should provide a data base that can be used for computer modelling of larger diameter vent ducts in typical Alberta one- and two-storey houses. This will involve the use of a prototype computer program that has been verified successfully.

The migration of moisture through the walls of one test module is being measured using single panels mounted in the north and south walls. Each panel contains glass fibre insulation and monitoring instruments. In studies thus far, the test module was preconditioned to an indoor relative humidity of 40 per cent, and then the amount of water released to the air was measured. Also measured were the natural infiltration rate, outdoor and indoor temperatures, wind speed and direction.

After determining the moisture generation rate, measurements were made of moisture migration through the building envelope. Also, moisture accumulation in the wall cavity was measured. Thus far, little accumulation was observed in the insulation, although some was noted in the exterior sheathing. This was more noticeable in the north wall, because solar heating effectively drove off any accumulated moisture in the south wall. Modifications were made to the test house for the next heating season. Instead of maintaining a constant indoor relative humidity, the moisture generation rate will be kept constant and the relative humidity will be allowed to fluctuate with natural air infiltration. The single wall test panel used until now was replaced with four assemblies. Also, an attic monitoring system was developed.

Wind Energy

The wind energy potential of southern Alberta has long been recognized. Although this area of the province is well-known for the chinook winds that bring relief from subzero temperatures several times each winter, what is less recognized is the fact that winds in southern Alberta are always present, averaging 3.6 m/s (8 mph) 353 days of the year.

In recent years, there has been a growing interest in capturing this wind for a variety of applications, ranging from electricity generation to water pumping for livestock watering or the creation of wetland habitats for waterfowl.

This has given rise to a steadily growing wind turbine-manufacturing capability in the area. The development and maturation of this industry is being aided by the Lethbridge Wind Research Test Site, an independent performance-testing facility that has been operating since 1983.

(Photo courtesy of Alberta Agriculture)

Demonstration and Testing of Small-Scale Wind Turbines

Alberta Agriculture, Lethbridge

At the Lethbridge Wind Research Test Site, the water-pumping performance and long-term reliability of wind turbines and solar-powered pumps continue to be monitored and evaluated.

In 1988/89, A/CERRF funding was provided for the seventh year to offset partly the costs of operating a site for independent testing of wind-powered and solar-powered water pumpers. This was done because the site is a valuable component in Alberta's developing solar and wind energy industry. Since the test site was established in 1982 (and became operational in 1983), the site operators have been inundated with requests from wind turbine manufacturers who would like to have their machines tested for performance and reliability.

Over the years, wind turbines tested at the site have evolved continually into improved products, and the industry as a whole is preparing for potential sales in international markets. This led to the development last year of a deep well simulator that allows testing at various pumping heads to simulate the greater depths from which water must be pumped in other countries.

Nine wind turbines and three solar-powered water pumpers were tested this year from May to October. Two other wind turbines were tested for short-term performance during the summer. Also, the deep well simulator was used all summer with three wind turbines. It performed as expected in allowing simulation of pumping from greater depths than are available at the test site. Over the winter months, the deep well simulator was used to test new pumps.

Test results are continuing to support earlier observations that the overall reliability of wind turbines is still not acceptable for sustained market development. Solar systems, on the other hand, are showing excellent performance, reliability and cost effectiveness.

Sales of wind turbines and solar pumpers in Alberta and Saskatchewan have increased as a direct result of the project, and hundreds of prospective buyers visit the test site each year. This past year, for example, it was observed that one or two telephone calls a day were received from farmers who were interested in purchasing water-pumping systems. Some of this, no doubt, was a result of the drought. Cattlemen, in particular, were willing to try water pumpers to help maintain their herds.

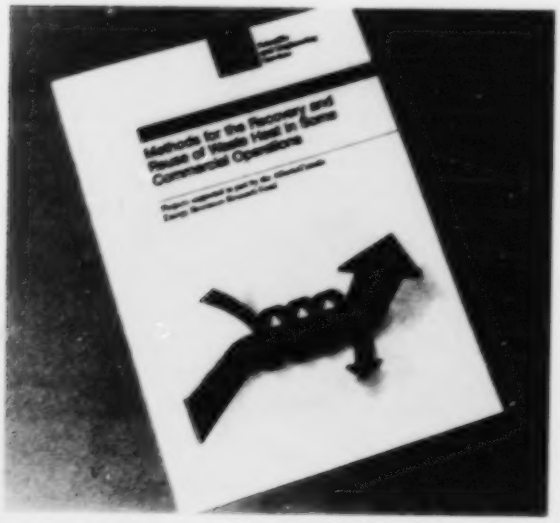
Those wind turbines and solar water pumpers not tested with the deep well simulator this year will be tested in 1989/90, and some additional performance and reliability testing will be performed.

Waste Heat Recovery/ Low Temperature Heat Utilization

Beginning in 1985, several projects were initiated to demonstrate the value of recovering waste heat or low temperature heat in various Alberta industries and businesses. For example, at Lakeside Feeders near Brooks, a condenser and a desuperheater installed in the discharge line of the refrigeration compressors recovered enough useful heat to preheat water used in the meat-packing process and displace the purchase of natural gas costing up to $31 000 annually. The cost savings associated with this installation were equivalent to a payback period of 15 months. Systems similar to this could be used in dairies, breweries and food-processing plants.

On a somewhat smaller scale, heat-recovery systems were installed at two commercial laundries in Calgary to extract heat from the warm wash water normally discharged into the sewer. The cost savings resulting from reduced purchases of natural gas amounted to payback periods of approximately four to five years for the two systems. It was estimated that similar installations in existing commercial, hospital, hotel/motel and coin-operated laundries could produce annual savings of $800 000 in Alberta.

In a similar vein, co-generation, the simultaneous production of electric and thermal energy from a single fuel source, is capable of saving half the fuel required to produce each energy form separately. This energy conservation method is believed to have some potential in Alberta and was the subject of two investigations this year.



Co-generation Demonstration in Commercial Buildings

Northwestern Utilities Limited, Edmonton

A 115 kW co-generator was installed at a commercial dry-cleaning establishment in Edmonton. Its operation will be monitored for one year.

(Photo courtesy of Northwestern Utilities Limited)

The objective of this three-phase project is to install and operate a gas-fired co-generation unit of up to 115 kW, and subsequently promote the concept's benefits to owners of commercial buildings.

In Phase I, a survey was made of 60 prospective buildings to identify those that might be suitable for installation of a co-generator. The researcher selected one of the commercial laundries owned by the Edmonton business firm, Cleaning by Page. Cost projections indicated that a 115 kW co-generator suitable for Page's needs would cost $100 000 and should have a payback period of five years. This estimate was based on displacement of electricity costing $12 a gigajoule and production of heat that will be used in the clothes-cleaning process.

The co-generator was received in November 1987 and installation (Phase II) was completed in May 1988. Mechanical problems were experienced soon after the unit began operating. These were not corrected until January 1989, causing a delay in initiating the Phase III monitoring work. The co-generator, however, has been operating since mid-January. It starts up automatically at 0730h and operates until 1730h each day. At year-end, the unit had operated for 600 hours. Its operation will be monitored for one year.

Co-generation Assessment Study

Southern Alberta Institute of Technology (SAIT), Calgary

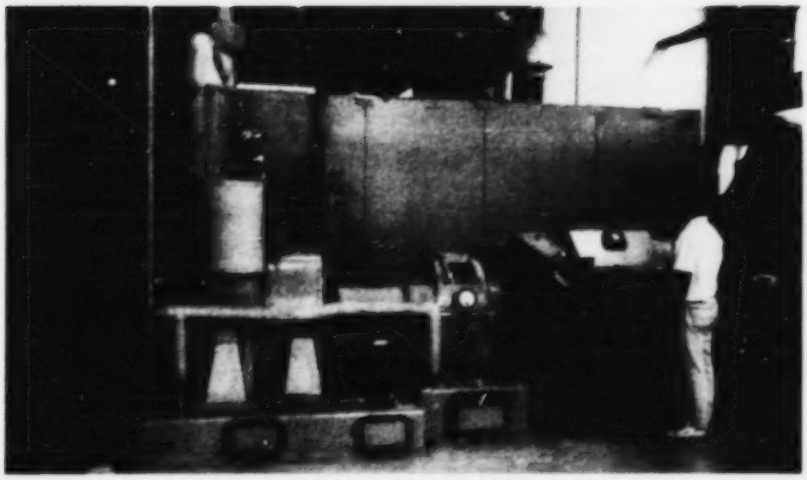
In this three-phase project, begun in 1985, the economics of co-generation in Alberta were determined under existing economic and capital cost conditions.

In Phase I, co-generation technology was reviewed, the cost effectiveness of co-generation systems was determined and regulatory issues related to co-generation were evaluated. In the Phase I report, received in September 1986, economic assessments indicated that potential exists for co-generation systems in operations where electricity demand is 500 kW or greater and the thermal load is both consistent and high. Computer simulations of a residential duplex, a restaurant and an office building showed only the office building was promising. It indicated that payback periods of 4.6 to 7.1 years were probable, depending on the type of co-generation equipment selected for the job. This suggested the remainder of the study should focus on larger facilities.

Phase II involved collection of data from operating co-generation systems at SAIT and Foothills Hospital. The data confirmed the earlier finding that co-generation is marginally feasible in Alberta if used in larger facilities where the thermal load follows the electrical demand.

The 150 kW steam turbine at the Southern Alberta Institute of Technology was operated under co-generation conditions at various heat and electricity loads in an assessment of the cost effectiveness of co-generation in Alberta.

(Photo courtesy of Southern Alberta Institute of Technology)



Phase III began in October 1987. It involved operating the 150 kW Gas Turbine Total Energy System at SAIT under co-generation conditions at various heat and electricity loads. Data indicated the system could be used economically when the thermal output was used to drive an absorption chiller. Evaluation of a Cheng Cycle co-generation plant indicated that higher efficiencies were available when the Heat-to-Power Ratio was variable. A list was prepared of types of industries and building services that were most amenable to co-generation systems. It was recommended that more should be done to encourage wider use of co-generation in Alberta.

The project has been completed.

Energy Conservation in Industry

Last year, a new subprogram was introduced to encourage energy conservation in industry or assist individual companies in capitalizing on opportunities to build, sell or operate energy conservation technologies.

Several intriguing proposals were received from industry, but most were large in scope and budget. Some of these proposals were too costly for the program, while others were subsequently withdrawn because of budget cuts in industry and government. Consequently, only one project was launched. It is a two-year investigation of the feasibility of recovering energy from municipal waste.

Recovery of Energy from Waste

Bow Valley Resource Services Ltd., Calgary

In 1987, the researcher proceeded with a detailed feasibility study and analysis of the potential for energy-from-waste facilities in Alberta. The study is evaluating current technology, environmental problems and uses for the produced energy when municipal wastes are incinerated, with particular emphasis on small-scale applications.

The researcher decided to do a detailed study of one community, using as much factual data as possible. This would be followed by sensitivity analyses to identify the most important factors in determining whether the economics are favourable. This should allow qualitative estimates to be made of energy-from-waste operations in other Alberta locations.

The town of Olds was selected as a hypothetical site for an energy-from-waste plant. This was partly based on an urgent need in this, and nearby communities, for proper waste disposal facilities. Also, the town was willing to co-operate in the study.

Sufficient data have been gathered to determine the viability of an energy-from-waste plant at Olds and to specify the plant size. Also, a conceptual design of the plant is being prepared, and its capital and operating costs are being calculated.

Data interpretation is under way and the final report is expected to be completed next year.

Hydrogen Technology Research

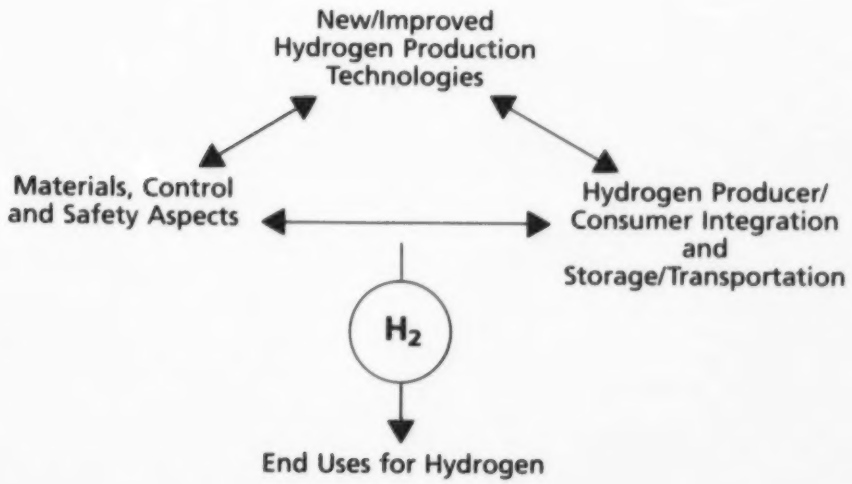
In August 1987, the Advisory Group on Hydrogen Opportunities, which had been established by the federal government in 1985, released a report recommending that a national "mission" be launched in Canada to develop advanced hydrogen technologies and capitalize on Canada's ability to become a leader in the race to the Hydrogen Age. As the largest producer and user of hydrogen in Canada, Alberta will have a major role to play in this technological evolution.

During the past 20 years, hydrogen use has been increasing steadily in several industrialized countries and there is a clear trend toward fuels and energy carriers having progressively higher hydrogen-to-carbon ratios. This movement is caused partly by diminishing supplies of light crude oils that many oil refineries are designed to handle. Consequently, refiners are obliged to hydro-treat less desirable crude oils to convert them into desirable refinery feedstocks. In Canada, supplies of all types of conventional crude oils are declining. This means that more refinery feedstocks must be made by hydro-treating heavy oils or bitumen derived from tar sands deposits. Hydrogen would also be needed in processes that might produce liquid fuels from Alberta's substantial coal resources.

Interest in hydrogen is also being driven by the adverse environmental effects of fossil fuel consumption; acid rain and the current controversy over the "Greenhouse Effect" are the two best-known examples. Therefore, some people see hydrogen as the primary fuel or energy carrier of the future and predict it will come into its own in the mid-21st century.

Following release of the report by the Advisory Group on Hydrogen Opportunities, the Alberta government demonstrated its support for the concept of a national mission by offering to become directly involved in its administration, and by spearheading the creation of an industry/government task force available to participate in any research program that might evolve.

Hydrogen Technology Research Program



Meanwhile, A/CERRF demonstrated its support for a possible hydrogen research program by funding a study in 1987/88 to identify: (1) current hydrogen production and consumption in Alberta; and (2) hydrogen technology developments that are required to improve hydrogen production, storage, transportation and use. The conclusions reached in this inventory study were released in April 1988.

It was found that Alberta industries produce 55 per cent and consume 63 per cent of all the hydrogen in Canada. Major near- and intermediate-term growth in hydrogen production and consumption is expected to occur in heavy oil and bitumen upgrading. However, the costs of hydrogen production currently represent a significant portion of overall upgrading costs. This means that new or improved technologies are required to lower production and handling costs, and these technologies should complement the development of Alberta's heavy oil, bitumen and coal resources.

In August 1988, a joint industry/government steering committee was created to formulate and oversee a hydrogen technology research and development program for Alberta. It would be funded on a cost-shared basis by A/CERRF and industry. Initially at least, this program is based on recommendations stemming from the inventory study and comprises four major components, each of which is considered to represent an aspect of hydrogen technology that requires commercial-scale development within 10 years. The components are:

- new and/or significantly improved hydrogen production technologies;
- optimum end-uses of hydrogen;
- hydrogen storage/transportation and resource, producer/consumer integration; and
- related material, control and safety aspects.

In December 1988, calls for proposals were sent out to prospective hydrogen researchers, who were asked to submit project proposals for possible funding in 1989/90. They were also informed that industry members of the Steering Committee supported the following funding formulas:

- Fundamental Research: up to 100 per cent A/CERRF contributions;
- Pre-competitive Research: 65 per cent A/CERRF, 35 per cent industry; and
- Competitive Research: 50/50.

Nineteen research proposals were received and appraised by a review and selection committee. Subsequently, seven projects were approved by the A/CERRF Committee for funding in 1989/90.

Technology Transfer

The principal findings of approximately 150 energy research projects funded by A/CERRF are being made available via technology transfer publications. Sixty of these projects deal with energy conservation and renewable energy.

Depending on the subject, publications are mailed to a list of 300 to 500 energy researchers, technical libraries and energy specialists employed by industry or government.

Technology Transfer and Dissemination

MacKenzie Environmental Consultants Ltd., Edmonton

The production of technology transfer booklets began in 1986. Thus far, 30 booklets describing 67 energy research projects have been published. Eighteen booklets covered energy conservation and renewable energy topics. The remainder described coal research and other conventional energy research projects.

The following energy conservation and renewable energy publications are available from:

Information Centre
Alberta Energy/Forestry, Lands and Wildlife
Main Floor, Bramalea Building
9920 - 108 Street
Edmonton, Alberta, Canada
T5K 2M4

Telephone: (403) 427-3590

Information Centre
Alberta Energy/Forestry, Lands and Wildlife
Main Floor, Britannia Building
703 - 6th Avenue S.W.
Calgary, Alberta, Canada
T2P 0T9

Telephone: (403) 297-6324

Solar Energy Potential for Alberta,
9 pages, March 1986.

A Practical Method for Defouling Heat Exchangers,
6 pages, March 1986.

Development of a Krypton Fluoride Laser
for Fusion Energy Research,
6 pages, July 1986.

Geothermal Energy Resources in Alberta,
10 pages, August 1986.

Measuring and Harnessing
Alberta's Wind Resources,
10 pages, October 1986.

Energy Management in Commercial Buildings,
8 pages, December 1986.

Control of Heat Loss Associated with
Overhead Doors,
6 pages, January 1987.

Practical Methods to Seal and Insulate
Residential Buildings,
9 pages, March 1987.

Energy-Conserving Characteristics of Common Building Materials and Methods.
14 pages. April 1987.

Performance Characteristics of Energy-Efficient Residential Furnaces.
9 pages. April 1987.

Some Methods of Insulating Basements. Walls and Windows.
10 pages. July 1987.

Development of Delta-Blade Wind Turbines.
10 pages. September 1987.

A Programmable Controller for Parking Lot Block Heaters.
9 pages. March 1988.

Some Methods of Saving Energy with Fluorescent Lighting.
8 pages. March 1988.

Methods for the Recovery and Reuse of Waste Heat in Some Commercial Operations.
9 pages. August 1988.

Some Energy-Conserving Concepts for Residential Buildings.
14 pages. November 1988.

The Development of Energy Conservation Demonstration Buildings in Alberta.
9 pages. January 1989.

Some Energy-Saving Measures for Commercial Buildings
9 pages. January 1989.

Appendices

Financial information on this year's projects, as well as sums expended to date on all A/CERRF-funded energy conservation and renewable energy projects, are provided in Appendix A.

Research reports that have resulted from some of these investigations, and are available for viewing at Alberta Energy's library in Edmonton, are listed in Appendix B.

Appendix A: Summary of Program Expenditures

A/CERRF Energy Conservation and Renewable Energy Projects and Expenditures to Date ($)

Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	Projected Future Funding	Total
General Energy Conservation														
Control of Energy Losses by Microbial Fouling of Heat Exchangers	-	23 768	67 628	3 999	-	-	-	-	-	-	-	-	-	95 395
Ice Nucleation Techniques for Defouling of Heat Exchangers	-	-	-	-	75 459	4 799	-	-	-	-	-	-	-	80 258
Using Thermal Discharges from Power Plants	-	9 653	5 347	-	-	-	-	-	-	-	-	-	-	15 000
Fuel and Fertilizer Production from Dairy Manure	-	6 176	17 148	-	-	-	-	-	-	-	-	-	-	23 324
Efficient Use of Low Heating Value Fuels	-	-	11 984	32 064	15 772	-	-	-	-	-	-	-	-	59 820
Streamline Device for Transport Trucks	-	-	665	5 995	2 256	-	-	-	-	-	-	-	-	8 916
Energy from Waste Wood (Sawmill Residues)	89 094	7 917	15 843	1 646	-	-	-	-	-	-	-	-	-	114 501
Efficiency of Rotary Piston Engine	9 213	2 644	-	-	-	-	-	-	-	-	-	-	-	11 857
District Heating Study	-	66 394	33 606	16 000	-	-	-	-	-	-	-	-	-	93 400
Energy Conservation in Sour Gas Processing	146 927	196 536	268 323	97 256	209 532	34 963	93 637	131 400	-	-	-	-	-	1 178 574
Subtotal — General Energy Conservation	**245 234**	**313 088**	**429 545**	**134 360**	**303 019**	**39 762**	**93 637**	**131 400**	**0**	**0**	**0**	**0**	**0**	**1 681 045**
Solar Energy														
Copper-Oxide Solar Cells	-	8 404	20 466	-	-	-	-	-	-	-	-	-	-	28 870
An Atlas of Solar Energy for Alberta	-	-	23 730	17 884	3 015	-	-	-	-	-	-	-	-	44 629
Application of Boiling and Condensation Heat Transfer for Flat Solar Collectors in Cold Regions	-	-	27 237	33 359	25 627	12 977	-	-	-	-	-	-	-	99 200
An Air-Mediated Solar Heating System with Long-Term Storage	-	-	15 706	26 907	-	-	-	-	-	-	-	-	-	42 613
An Advanced Control Approach for Solar Heating Systems	-	-	-	-	10 219	3 621	-	-	-	-	-	-	-	13 840
Subtotal — Solar Energy	**0**	**8 404**	**87 139**	**78 150**	**38 861**	**16 598**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**229 152**
Geothermal Energy														
Research on Alberta's Geothermal Energy Resources	-	18 063	43 286	75 298	60 399	83 704	57 463	-	-	-	-	-	-	338 213
Subtotal — Geothermal Energy	**0**	**18 063**	**43 286**	**75 298**	**60 399**	**83 704**	**57 463**	**0**	**0**	**0**	**0**	**0**	**0**	**338 213**

Program Expenditures (continued)

Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/ 6	1986/87	1987/88	1988/89	Projected Future Funding	Total
Fusion Energy														
Laser Fusion Energy Research		5 784	56 111	122 995	144 855	152 927	146 987							629 659
Subtotal - Fusion Energy	**0**	**5 784**	**56 111**	**122 995**	**144 855**	**152 927**	**146 987**	**0**	**0**	**0**	**0**	**0**	**0**	**629 659**
Energy Conservation in Buildings														
Alberta Home Heating Research Facility		2 825	142 705	44 740	33 990	19 524								243 784
Insulation Properties of Flat Built-Up Roofs		19 268	6 584	13 930	8 176	7 980								55 938
Passive Solar Heated Community Center				2 050	10 120	2 000								14 170
Energy Efficient Masonry Fireplace						48 820								48 820
Edmonton Energy Conservation Center								51 920	25 000					76 920
Self Help Retrofit Manual for Owners of Multi-Family Housing Units							1 745	12 805	10 850					25 400
Retrofit Wall System for Residential Housing							342	2 540	6 998					9 880
Energy Savings and Payback of Retrofit Basement Wall Insulation							506	8 435	3 883					12 824
Energy Efficient Housing Display Program					221 332	3 614	3 384	2 650		3 020				234 000
Townhouse Retrofit Demonstration							6 477	11 049	2 514					20 040
A Survey of Air Leakage in Alberta Homes							15 709	40 071	4 376					60 156
Construction and Testing of a Masonry Module							9 931	15 237	5 896					31 064
Concrete Masonry Walls for Thermal Storage, Heating and Insulation							5 860	10 440	(1 630)					14 670
Computer Program for Analysis of Thermal Mass									24 314	1 641				25 955
Sizing of Warm Air Furnaces for Residential Use							3 192	127						3 319
Development of Higher-Efficiency Gas-Fired Furnaces							4 376	35 624	30 000					70 000
Seasonal Efficiency of Residential Natural Gas Furnaces								20 261	12 738	1 190				34 189
Development of an Insulating Curtain for Residential Installation							8 047	25 917						33 964
Residential Air-to-Air Heat Exchanger Using Heat Pipe Technology							943	5 968	4 192	1 448				12 551
Energy Conservation in Public Swimming Pools							9 969	20 236	1 635					31 840

Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	Projected Future Funding	Total
Development of a User-Friendly Computerized Building Management System	-	-	-	-	-	-	4 928	37 281	26 914	477	-	-	-	69 600
Multi-Zone Setback Thermostat	-	-	-	-	-	-	8 359	28 553	4 048	-	-	-	-	40 960
A New Heat-Conserving Control System for Warehouse-Type Buildings	-	-	-	-	-	-	3 538	17 782	9 654	-	-	-	-	30 974
Demonstration of a Cost-Effective Energy Management System	-	-	-	-	-	-	8 427	8 359	-	-	-	-	-	16 786
A Ventilation Control System Based on Carbon-Dioxide Levels	-	-	-	-	-	-	604	750	-	-	-	-	-	1 354
Inventory of Building Design and Analysis Computer Programs and a Weather Input Data Base for Alberta	-	-	-	-	-	-	1 484	36 063	-	-	-	-	-	37 547
Energy-Efficient Fluorescent Lighting Ballast	-	-	-	-	-	-	19 565	30 371	-	-	-	-	-	49 936
Computer Simulations for Mechanical Systems in Buildings	-	-	-	-	-	-	8 886	27 885	11 538	-	-	-	-	48 309
Programmable Controller for Parking Lot Block Heater Service	-	-	-	-	-	-	-	-	7 554	2 868	-	-	-	10 422
Comprehensive Retrofit Measures in Commercial Buildings	-	-	-	-	-	-	-	-	14 552	-	-	-	-	14 552
Retrofit Curtain for Overhead Doors	-	-	-	-	-	-	-	-	13 656	3 493	-	-	-	17 149
Demonstration of Mini-Fluorescent Lighting	-	-	-	-	-	-	-	-	2 700	3 235	-	-	-	5 935
Survey of Energy Efficient Furnaces	-	-	-	-	-	-	-	-	20 282	14 167	-	-	-	34 449
Swimming Pool Dehumidification Demonstration	-	-	-	-	-	-	-	-	4 700	20 234	987	-	-	25 921
Peak Electrical Demand Reduction Through Co-generation	-	-	-	-	-	-	-	-	5 745	8 376	5 183	12 248	-	31 552
Demonstration of Free Cooling in Building Humidification Systems	-	-	-	-	-	-	-	-	2 600	15 323	6 988	4 839	-	29 750
Demonstration of Low Emissivity Ceilings in Alberta Arenas	-	-	-	-	-	-	-	-	8 102	28 517	2 229	-	-	38 848
Energy Conservation in Housing	-	-	-	-	-	-	-	-	-	-	77 786	68 234	59 980	206 000
Subtotal — Energy Conservation In Buildings	**0**	**22 093**	**149 289**	**60 720**	**273 618**	**81 938**	**126 272**	**450 324**	**262 811**	**103 989**	**93 173**	**85 321**	**59 980**	**1 769 528**

Program Expenditures (continued)

Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	Projected Future Funding	Total
Wind Energy														
Comparison of Wind Turbines	-	-	-	-	10 686	14 310	-	-	-	-	-	-	-	24 996
Demonstration and Testing of Small-Scale Wind Turbines	-	-	-	-	-	72 386	47 324	34 408	61 974	46 938	39 996	57 982	50 000	411 008
Solar and Wind Energy Research	131 731	539 332	310 813	256 673	334 809	233 699	254 195	237 605	187 681	-	-	-	-	2 486 538
A Large Delta-Blade Wind Turbine, An Alberta Development	-	-	-	-	92 945	170 400	477 772	35 294	108 222	39 778	-	32 550	5 460	962 421
Subtotal — Wind Energy	**131 731**	**539 332**	**310 813**	**256 673**	**438 440**	**490 795**	**779 291**	**307 307**	**357 877**	**86 716**	**39 996**	**90 532**	**55 460**	**3 884 963**
Waste Heat Recovery/ Low Temperature Heat Utilization														
Grey Water Heat Recovery from Commercial Laundries	-	-	-	-	-	-	-	-	36 906	72 949	-	-	-	109 855
Heat Recovery in a Recreation Facility	-	-	-	-	-	-	-	-	5 707	-	-	-	-	5 707
Heat Recovery in a Meat-Packing Plant	-	-	-	-	-	-	-	-	14 089	47 956	8 534	-	-	70 579
Heat Recovery in a Full-Service Dairy	-	-	-	-	-	-	-	-	12 912	1 267	-	-	-	14 179
Co-generation Demonstration in Commercial Buildings	-	-	-	-	-	-	-	-	1 267	12 098	50 756	2 400	39 340	105 861
Co-generation Assessment Study	-	-	-	-	-	-	-	-	14 758	16 244	40 827	2 003	-	73 832
Utilization of Waste Heat for Crop Production	-	-	-	-	-	-	-	-	16 395	-	-	-	-	16 395
Subtotal — Waste Heat Recovery/Low Temperature Heat Utilization	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**102 034**	**150 514**	**100 117**	**4 403**	**39 340**	**396 408**
Energy Conservation in Industry														
Recovery of Energy from Waste	-	-	-	-	-	-	-	-	-	-	42 568	39 036	38 196	119 800
Subtotal — Energy Conservation in Industry	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**42 568**	**39 036**	**38 196**	**119 800**
Total — Energy Conservation and Renewable Energy Projects	**376 965**	**906 764**	**1 067 183**	**728 196**	**1 259 192**	**865 724**	**1 203 650**	**889 031**	**722 722**	**341 219**	**275 854**	**219 292**	**192 976**	**9 048 768**

Project Title	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	Projected Future Funding	Total
Hydrogen Technology														
Hydrogen Technology Inventory Study for Alberta	-	-	-	-	-	-	-	-	-	-	47 874	-	-	47 874
Hydrogen Technology Program Planning and Implementation Assistance	-	-	-	-	-	-	-	-	-	-	-	5 805	90 000	95 805
Production of Hydrogen and Sulphur from Hydrogen Sulphide	-	-	-	-	-	-	-	-	-	-	-	-	147 000	147 000
Partial Oxidation of Methane for Production of Hydrogen and/or Synthesis Gas	-	-	-	-	-	-	-	-	-	-	-	-	148 830	148 830
Total — Hydrogen Technology	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**47 874**	**5 805**	**385 830**	**439 509**
Technology Transfer and Dissemination	-	-	-	-	-	-	-	-	-	**82 144**	**69 917**	**128 275**	**200 000**	**480 336**
Total	**376 965**	**906 764**	**1 067 183**	**728 196**	**1 259 192**	**865 724**	**1 203 650**	**889 031**	**722 722**	**423 363**	**393 645**	**353 372**	**778 806**	**9 968 613**

Appendix B: Publications List

The following project reports, prepared by research contractors whose investigations were supported by A/CERRF, are available for viewing at:

Library Services
Alberta Energy/Forestry, Lands and Wildlife
9th Floor, South Tower, Petroleum Plaza
9915 - 108 Street
Edmonton, Alberta, Canada
T5K 2C9

Telephone: (403) 427-7425

General Energy Conservation

Western Research and Development. 1978. Claus Plant Waste Gas Incinerators.

MacKenzie, F.B. and A.H. Laycock. 1979. Thermal Power Plant Waste Heat Utilization in Alberta: Potential and Problems. University of Alberta.

Paskall, H.G. 1979. Capability of the Modified Claus Process. Western Research and Development.

SNC Tottrup Services Ltd. 1979. Study on Energy and Chemicals from Wood.

Feddes, J.J.R., J.B. McQuitty and J.T. Ryan. 1980. Fuel and Fertilizer Production from Dairy Manure. University of Alberta.

Stanley Associates Engineering Ltd./Ekono Engineering Consultants. 1980. Edmonton District Heating Study - Financial Feasibility.

Bow Valley Research Ltd. 1981. Catalytic Incineration of Sulphur Plant Waste Gases.

Bow Valley Research Ltd. 1981. Recuperative Heat Exchange Incinerator Pilot Plant.

Karim, G.A. 1982. The Efficient Utilization of Low Heating Value Fuels. University of Calgary.

McKenzie, R.P. 1982. A Streamline Device for Trucks and Buses.

Bow Valley Research Ltd. 1985. An Energy Audit Strategy for Gas Plants.

Solar Energy

Nkemdirim, L.C. 1981. A Solar Energy Atlas for Alberta, Volumes I and II. University of Calgary.

Robinson, A.M. 1981. Study of Air-Mediated Solar Heating Systems with Long-Term Storage. University of Alberta.

Cheng, K.C. 1982. Application of Boiling and Condensation Heat Transfer to Flat Plate Solar Collectors in Cold Regions. University of Alberta.

Rink, R.E. and H.Q. Le. 1982. A Study of Improved Control Strategies for Bilinear Heat Transfer Processes in a Solar-Assisted Heat Pump System. University of Alberta.

Alberta Research Council. 1986. Solar and Wind Energy Research Program (SWERP) Information Centre.

Geothermal Energy

Jones, F.W., H.L. Lam and T.N. Nasr. 1981. An Investigation of Geothermal Energy Resources of Alberta. University of Alberta.

Jones, F.W., H.L. Lam, M. Rahman and D. Yuen. 1982. A Detailed Study of Regions of Geothermal Energy Potential in Alberta. University of Alberta.

Jones, F.W., M. Rahman, H.L. Lam and J.E. Sworder. 1983. A Preparatory Study for Application of Geothermal Energy in the Hinton/Edson Area of Alberta. University of Alberta.

Fusion Energy

Offenberger, A.A., D.C.D. McKen and R. Fedosejevs. 1981. CO_2 Laser-Heated Solenoid Research and High Power Krypton Fluoride Laser Development for Fusion Energy Research. University of Alberta.

Offenberger, A.A., D.C.D. McKen and R. Fedosejevs. 1983. High Power Krypton Fluoride Laser Development for Fusion Energy Research. University of Alberta.

Energy Conservation in Buildings

Gilpin, R.R., J.D. Dale, T.W. Forest and M.Y. Ackerman. 1980. Construction of the Alberta Home Heating Research Facility and Results for the 1979-1980 Heating Season. University of Alberta.

Alberta Roofing Contractors. 1981. The Attachment of Insulation to Existing Built-Up Roofs.

Gilpin, R.R., T.W. Forest, M.Y. Ackerman, D.G. Wilson, G.W. Sadler, J.D. Dale and M. Zaheeruddin. 1981. Second Annual Report on the Alberta Home Heating Research Facility: Results for the 1980-81 Heating Season. University of Alberta.

HUDAC Alberta Council. 1982. A Project to Build and Display Energy-Efficient Single Family Homes in Alberta.

Ackerman, M.Y. 1983. A Study of Residential Housing Envelope Heat Losses. University of Alberta.

Ackerman, M.Y., J.D. Dale, T.W. Forest, G.W. Sadler, D.J. Wilson and M. Zaheeruddin. 1983. Final Report on the Alberta Home Heating Research Facility: Results of the 1981-82 Heating Season and Part of the 1982-1983 Heating Season to January 1983.

Zaheeruddin, M. 1983. A Simulation Model for a Direct Gain Passive House and Its Experimental Verification. University of Alberta.

Kostiuk, L.W. and J.D. Dale. 1984. Thermal Performance of an Insulated Masonry Structure: Results of the 1983-84 Heating Season. University of Alberta.

J.E. Sworder Engineering. 1984. Report on the Selection of Warm Air Furnaces for Residential Housing.

Vinto Engineering Ltd. 1984. Report on Inventory of Computer Programs.

Kasten Eadie Engineering Ltd. 1985. Conceptual Report for Waste Heat Recovery from the Refrigeration Unit at the Okotoks Triplex Arena.

Magna IV Engineering Ltd. 1985. Technical Feasibility and Cost Study of Programmable Controller for Parking Lot Block Heater Services.

Sunergy Systems Ltd. 1985. R&D of an Insulating Curtain for Residential Application.

Tomorrow Foundation. 1985. The Edmonton Energy Conservation Centre - Phase I Retrofit.

Vinto Engineering Ltd. 1985. Report on Development of an Alberta Weather Input Data Base.

Adept Engineering. 1986. Comprehensive Retro-fit Measures in Commercial Buildings, Phase I.

Bill Johnston Architect Ltd. 1986. A Survey of Air Leakage in Calgary Homes.

Byrne, A.P. and T.G. Lee. 1986. Development of a Computer Program for Analysis of Thermal Mass in Buildings. University of Calgary.

Greeley, D.S. 1986. Energy Savings and Payback with Basement Wall Insulation Retrofit. Dow Chemical Canada Inc.

Kasha, J.F. and J.D. Dale. 1986. A Study of the Performance of Six Residential Natural Gas Furnaces. University of Alberta.

Lamb McManus Associates Ltd. 1986. Swimming Pool Dehumidification Demonstration - Phase I Report.

Magna IV Engineering Ltd. 1986. Programmable Controller for Parking Lot Block Heater Services.

Mayhew, W.J. and D.G. Howell. 1986. Survey of Medium- and High-Efficiency Gas Furnaces. Howell Mayhew Engineering Inc.

Staszenski, B. 1986. Edmonton Energy Conservation Centre, Phase II Final Report.

Sunton Engineering Ltd. 1986. Demonstration of Low Emissivity Ceilings in Arenas, Phase I.

Sunton Engineering Ltd. 1986. Demonstration of Low Emissivity Ceilings in Arenas, Phase II.

Vardabasso, M. and T. Grusendorf. 1986. Cogeneration Assessment Study, Phase I.

Whitaco Holdings Ltd. 1986. Cost-Effective Energy Management System.

Alberta Home Builders' Association. 1987. Energy Efficient Housing Display Program - Final Report.

Dale, J.D. and M.Y. Ackerman. 1987. Research Needs in Radiant Floor Heating.

Love, J.A. 1987. Demonstration of Minifluorescent Lighting: Phase II.

Ostrowski, J. and H. Ostrowski. 1987. Retrofit Wall System for Residential Housing. ARE-Alternative and Retrofit Energies Inc.

Ostrowski, J., H. Ostrowski and R. Chapla. 1987. Self-Help Retrofit Manual for Owners of Multifamily Housing Units.

Williams, P.G. and C.T. Grusendorf. 1987. Residential Air-to-Air Heat Exchanger Using Heat Pipe Technology. EMC Energy Management Consultants Ltd.

Wind Energy

The Dalcor Group. 1982. Comparison Study of Wind Turbines.

Paterson, B.A., D.R. Baker and N.E. Jensen. 1985. Evaluation of Low Volume Wind Turbines for Pumping Water.

Baker, D.R. 1986. Survey of Wind Turbine Installations in Alberta in 1981. DRB Engineering Consultants Ltd.

Baker, D.R. 1986. Performance Test Results of the Deltx WP50 Windpump Prototype.

Paterson, B.A., D.R. Baker and N.E. Jensen. 1988. Lethbridge Wind Research Test Site Evaluation of Wind and Solar Pumping Systems, 1985-1987.

Waste Heat Recovery

Crawford Consulting Engineering Ltd. 1985. Waste Heat Recovery in a Meat-Packing Plant, Phase I.

Crawford Consulting Engineering Ltd. 1985. Heat Recovery in a Meat-Packing Plant: Phase II.

Adept Engineering. 1986. Grey Water Waste Heat Recovery in Commercial Laundries: Phase I.

Crawford Consulting Engineering Ltd. 1987. Heat Recovery in a Meat-Packing Plant - Final Report.

Additional copies of this review are available from:

Information Centre
Alberta Energy/Forestry, Lands and Wildlife
Main Floor, Bramalea Building
9920 - 108 Street
Edmonton, Alberta, Canada
T5K 2M4

Telephone: (403) 427-3590

Information Centre
Alberta Energy/Forestry, Lands and Wildlife
Main Floor, Britannia Building
703 - 6th Avenue S.W.
Calgary, Alberta, Canada
T2P 0T9

Telephone: (403) 297-6324

Detailed information on any project funded by the Alberta/Canada Energy Resources Research Fund is available from:

Director
Energy Conservation and Renewable Energy Research
Scientific and Engineering Services and Research Division
Alberta Energy
3rd Floor, Blue Cross Place
10009 - 108 Street
Edmonton, Alberta, Canada
T5J 3C5

Telephone: (403) 427-8042

Telex: 037-3676

Fax: (403) 422-0975